IMPROVEMENTS

IN

LOCOMOTIVE ENGINES,

AND

RAILWAYS.

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MECHANICAL ENGINEER,

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Gift of
the family of the late
Prof. Th[illegible] Parsons,
of Cambridge.

IMPROVEMENTS IN LOCOMOTIVE ENGINES.

In presenting the following improvements to the public, and to those particularly who are interested in the extension of the Rail Road system, I feel assured that they will meet with an impartial and careful investigation, being strengthened in this belief by the reception which they have already met with from many of our most eminent engineers, who have examined them: letters from some of whom will be found at the end of this pamphlet.

The object I have had in view, in making the improvements, which I am about to describe, in Locomotives, Engines and Rail Roads, has been to induce the extension of Rail Roads beyond the limits prescribed by the present system of Rail Road engineering.

The period has arrived, when the benefits of Rail Roads should no longer be denied to those sections of country where their construction has hitherto been deemed impracticable, by reason of the enormous expense of removing or overcoming the natural obstructions. In this widely extended country there are vast tracts of arable land, as well as abounding in mineral wealth, which need but the facilities of communication with the great marts in order to develope their value, but which must lie unimproved for a long time, unless some great improvements upon the present system of engineering be adopted, which shall combine feasibility with economy. There are many districts where nature has placed barriers to their approach, which cannot be removed or cut through: many of the most valuable mineral lands are at such elevations as to be reached only by the use of steep inclined planes, and stationary machinery of great cost—entirely beyond the present means of those interested in their development.

I have been, for a long time, deeply impressed with the vast importance of adopting some method by which to overcome the natural difficulties presented in extended lines of railway, as well as in branch roads connecting with the great Rail Roads, and by so doing to increase their value, and at the same time extend their usefulness. Since 1837, at which time I was engaged in Locomotive building, I have watched, with great interest, the progress of the

system of Rail Road engineering. In the early stages of engineering, the roads were graded to an almost perfect level—inclined planes and stationary power being employed for the purpose of rising from one level to the next. The inconveniences and insecurity incident to this system have induced a change in the Rail Road system of late years, viz: the overcoming the elevations, as far as practicable, by a gradual ascent, ranging as high as 100 feet per mile, and employing locomotive power throughout. The security of travel and transportation is immeasurably enhanced by this method, for the danger arising from a break in the train on such grades is almost as nothing compared with that from the rupture of the ropes on an inclined plane. Nor is the liability of such an accident so great in the one instance as in the other, from the very nature of the case. It is easier, and less expensive, to give and maintain the requisite strength to the machinery employed in the use of locomotive, than in stationary power. In the former case, as the grades are at a less elevation, and, consequently, the gravitating or descending tendency is not so great, and all the attachments are of such a character that they can be made of any desired strength: whilst, in the case of the inclined plane, the ascent is much steeper, and, consequently, the tendency to descend much greater, requiring very great strength in the ropes to which the cars are attached: and, as every part of these ropes is successively subjected to the whole strain, the greatest care is required to prevent accidents. It is plain, therefore, that in point of security, the present system is vastly superior to the old method of ***locking up***, as an eminent engineer has termed the inclined plane system. Besides, it is very generally conceded that it is more economical, when we take into the account the delays at the inclined planes, the number of persons employed, the expenses for repairs and renewal of the ropes, and the strength of machinery required to elevate an enormous weight at a great elevation.

The present system has, however, led to the employment of engines of a heavier description than those formerly used, in order to carry their trains over the grades; in some instances engines having been used which weighed 30 tons and upwards, ten and twelve tons being the average weight of the earlier locomotives. Engines of such enormous weight demand an increased weight of rail, and a greater strength in the superstructure of the road, as also a correspondingly increased strength of bridging, &c. thus adding vastly to the cost of the road. In many, if not in most of the Rail Roads, the grades are of such length and number, as to render it expedient to use the same locomotive on the levels and the grades, and the consequences of running such enormous weights at high velocities over the level parts of the road, are ruinous in the highest degree to the rails and superstructure of the road. The great cost therefore of Rail Roads upon the present system, in the outset, and the expensive repairs resulting from the ravages of the enormous locomotives, are sufficient to prevent the rapid and profitable extension of roads and branches, which would follow upon the introduction of lighter locomotives, which shall at the same time be capable of overcoming the gradients with certainty and security.

In new sections of country, and in those where the inequalities of the surface are great. the use of light locomotives varying in weight from 6 to 12 tons, is therefore a great ***desideratum***, and one which can only be supplied by some means of traction, other than the weight of the locomotive. Various devices have been suggested or tried for this purpose, Gearing wheels operating on a rack laid upon the centre or sides of the track:—connecting

all the wheels in the train with the engines of the locomotive—besides many others. Experience, however, has shown that the adhesion of plain wheels upon an iron rail serves best for the practical purposes of locomotion, and also that it is ***essentially important*** that all the machinery of locomotion be confined to the locomotive. To combine the advantages of both systems, and to obviate their defects, has therefore been the object of my present improvements, the leading features of which are as follow:

1. To obviate the necessity of heavy cuttings, long and expensive embankments, or circuitous routes, in order to reduce the road to a level.

2. To cheapen the cost of construction by the use of lighter rails and superstructure.

3. To construct locomotives of so light weight, that at the highest velocities they shall not destroy the rails, and so contrived as to be able to carry the trains over the grades at the reduced speed due to the increased power required, at the same time having an adjustible adhesion or tractive power, capable of being suited to the state of the rails, or the load to be drawn.

4. In case of a break in the train, to be able to arrest the motion of the train, with the greatest possible safety to passengers, cars, and road.

The accomplishment of the objects named in the first two sections, follows as a consequence upon the construction of the locomotives mentioned in the third.

My locomotive is very similar in its construction and appearance to those now in use, and in short may be said to be precisely similar to them, as far as working the levels is concerned, but, in ascending or descending the gradients, I employ the resistance of the train to produce an adhesive or tractive power, in addition to that of the ordinary driving wheels. This resistance of the train, or load to be drawn, is made to act upon plain wheels operating on the opposite sides of an iron central rail, combining within the locomotive all the requisite machinery, levers, &c. to produce the requisite adhesion, and to revolve the wheels, and produce motion in the train. I thus produce an adhesion by ***pressure***, instead of an adhesion by ***weight***. It is plain to perceive that as this pressure is equal upon both sides of the rail, it is felt only by the iron of the rail itself, and not at all by the superstructure of the road; for there will be no tendency to move the rail in its position, or to bend it from a right line. The only limit, therefore to the amount of tractive power to be produced in this way, is the cohesion of the iron itself.

This adhesion being produced by the resistance of the load to be drawn, is in exact proportion to the amount of that resistance, so that there is no possibility of loading an engine beyond its adhesion, as is the case with the adhesion produced by the weight of the engine, that being the same always. Besides, the engine is not required to overcome unnecessary friction, caused by an undue pressure on the axles of the driving wheels as is the case with engines of the present construction, when carrying trains much lighter than they are capable of drawing.

Adopting this principle of a ***balanced adhesion by pressure***, the grand element of locomotion is obtained in a manner which obviates the necessity of the expensive superstructure which the adhesion by weight requires.

A more extended review of the two kinds of adhesion will be found in another part of this pamphlet.

Locomotives when constructed, with their whole weight distributed upon their driving wheels, may, when the rails are in the best condition, exert their full effective force, but, when the rails become wet, or out of order, from any other cause, they lose their hold-fast, and the wheels slip round without moving the train. To correct this evil, alone, is a matter of great importance, and many devices have been resorted to for that purpose, and the one most generally adopted is the most destructive to the rails and engines, I mean the sand-box, which supplies the cutting material ready for use in the process of grinding away both rails and wheels.

The question naturally arises, whether, in the present construction of locomotives, care has been taken to proportion the power so as to have the greatest amount of power with the least weight in the engine, or has not the engine been increased in weight to give adhesion in proportion to the power—thus adding a dead, unproductive load to be carried and re-carried over the road, to the exclusion of so much freight that should be productive? From my own observation, I am satisfied that the latter is the case, and that much weight in the Locomotive may be dispensed with, without injury to the machine.

There is, also, much room for improvement in the construction of the boiler. The necessity of some other plan, or modification of the present plan, becomes apparent when heavy grades are to be worked, as the water in the long boilers now in use will be subject to too much change of level in ascending or descending gradients, either leaving the top of the fire-box or the ends of the flues unprotected against the direct action of the fire. By confining the water level within the dome-part of the boiler, this difficulty is effectually obviated, at the same time that it allows an increased fire surface by filling the whole body of the boiler with flues, and, when combined with the system of circulation which I have adopted, will prevent *foaming* or *priming*, which would otherwise be the result of a diminished steam surface—the steam chamber being confined to the dome. By increasing the heating surface we increase the effective power; or, which is the same, we may use smaller boilers, and, consequently, reduce the weight. The importance of the reduction of the weight of the machinery of locomotion, to the cheap construction of Rail Roads, is too obvious to need further comment.

On grades of over 200 feet per mile, the common brake will, when well attended to, secure the safety of passengers, as descending grades of more than 300 feet per mile have been successfully worked by the brakes; yet, the frequent want of proper attention has induced me to apply self-acting brakes, which, in case of a break in the train, in ascending a grade, the brake is disengaged from its suspended position, and falls, closing in its descent and gripping the central rail, immediately arrests the cars in their descent, before they have acquired any momentum. This arrangement insures perfect safety to the passengers, as no retrogade motion can take place, if, by accident, the train should be disengaged in any part.

Having shown the objects of my improvements, I will now proceed to a description of them, reference being had to the accompanying plates. Plate I is a side elevation of the model engine. This model was built with great care, and on a scale which would render its operation as effective a test of the principle as a full sized engine would have been. The general construction is similar to that of the common eight-wheeled engine;—such devia-

Plate I

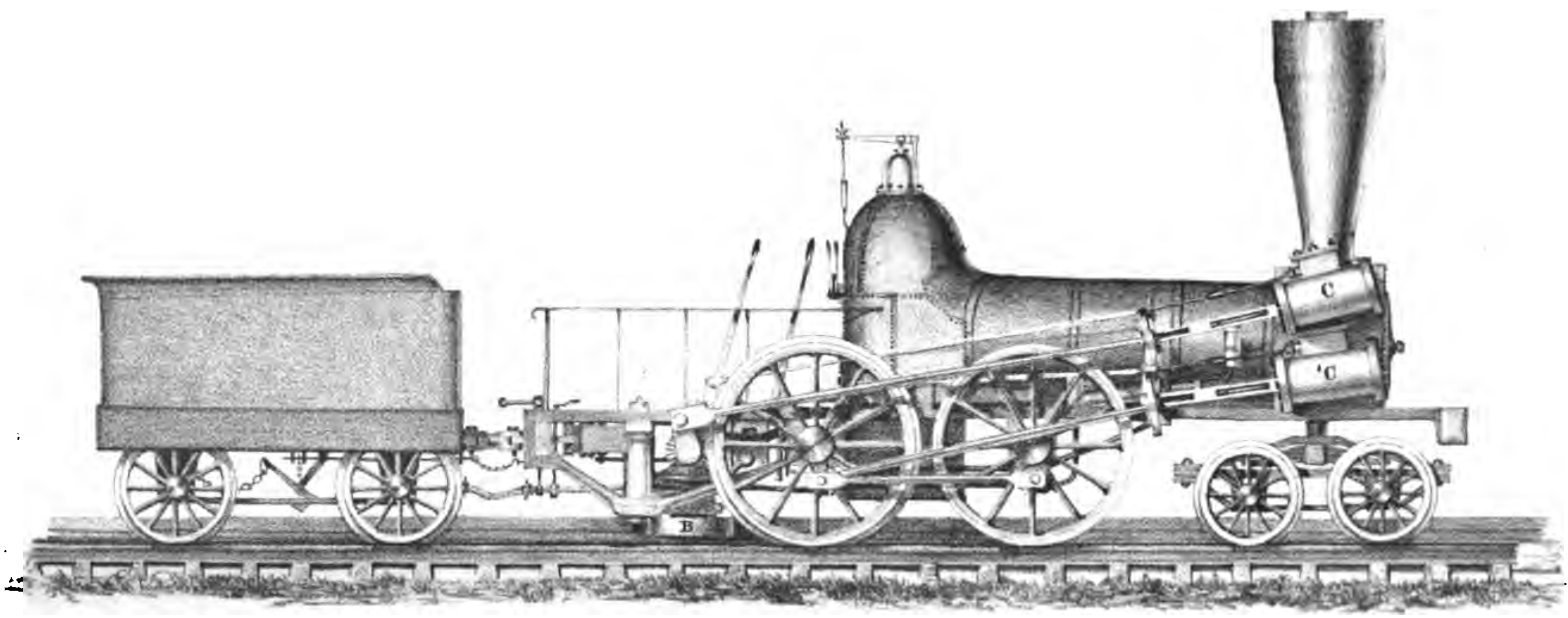


Plate II.

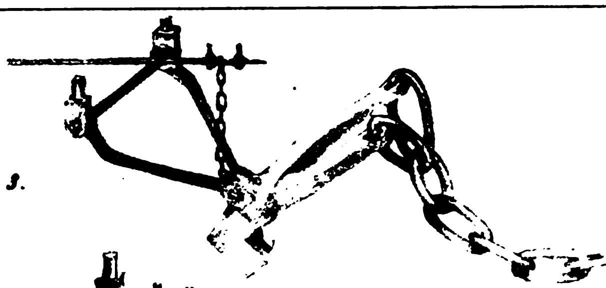


Fig 3.

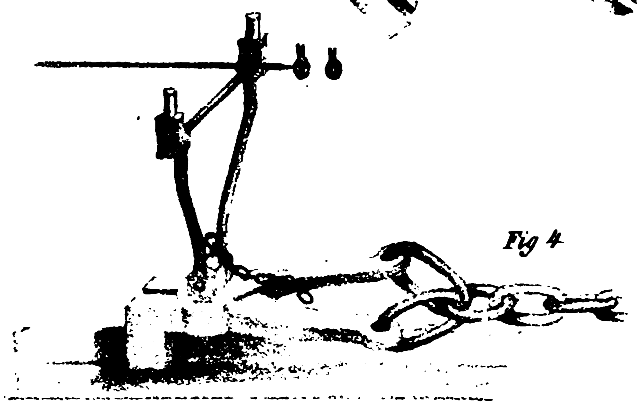


Fig 4

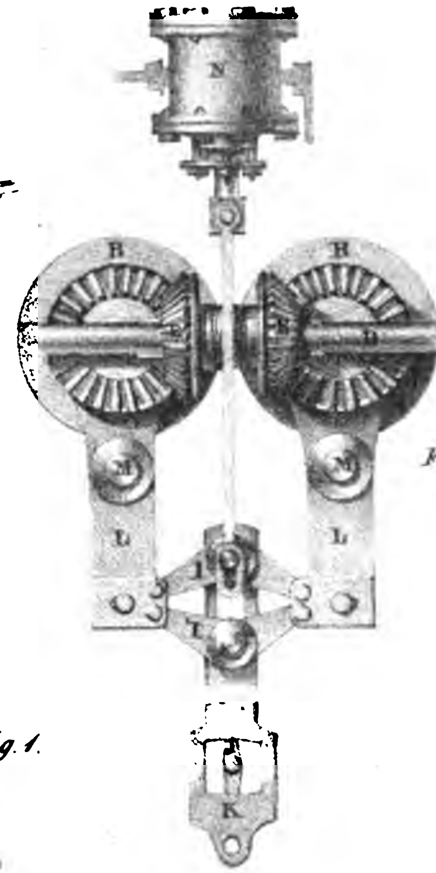


Fig 2

Fig. 1.

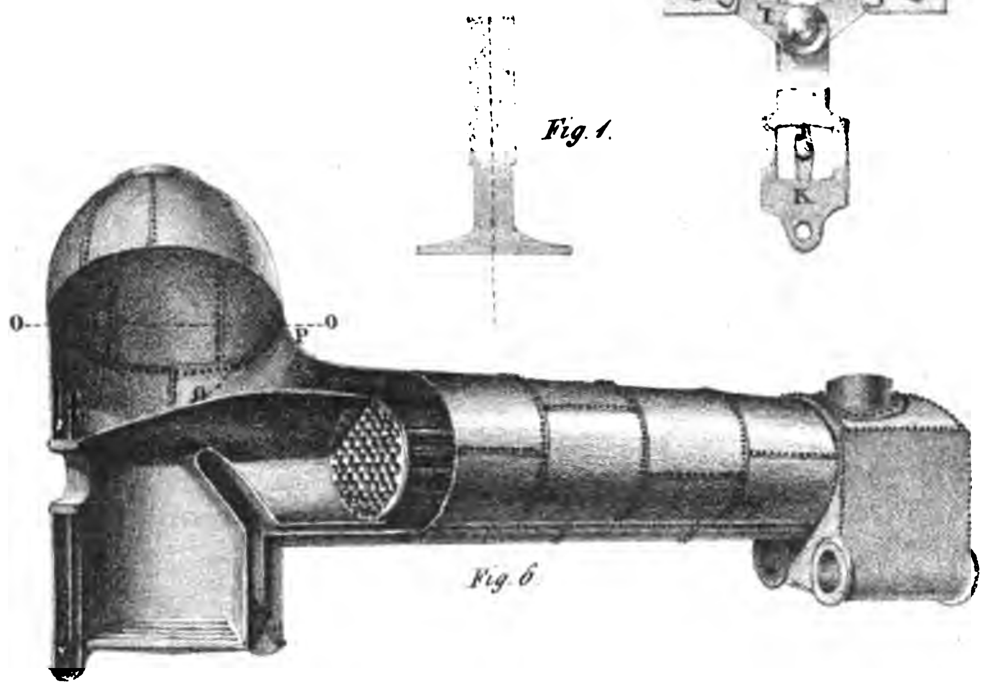


Fig. 6

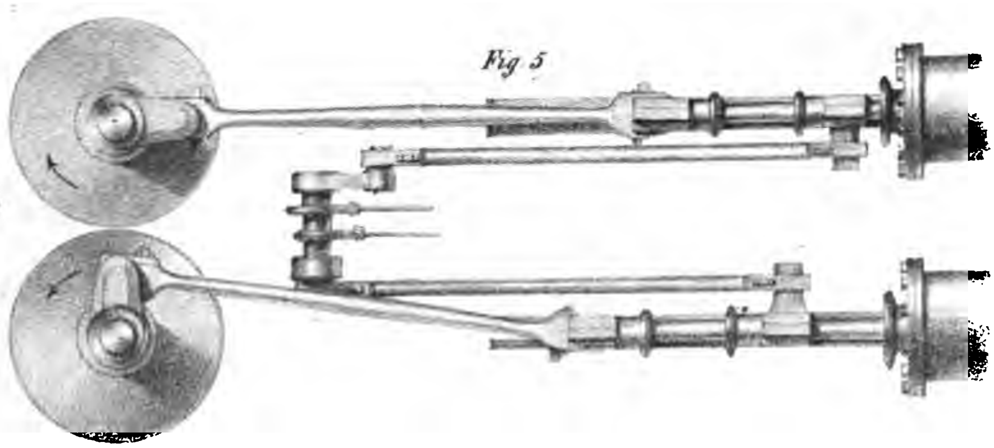


Fig. 5

tions only having been made as were unavoidable in obtaining the requisite strength of parts. These deviations have, of necessity, given a greater weight upon the side driving wheels than they would proportionately bear in the engine of the full size, and, therefore, giving more adhesion upon the rails than would exist in the large engine, consequently, giving an undue advantage in the experiments upon the level road to the principle of the ordinary locomotive, but, nevertheless, rendering the advantages of my system the more apparent.

The boiler is made of copper; the cylindric part, or body, is 12 inches in diameter, flues 21 inches long and 62 in number, 55 being 11-16th of an inch and 7 being 1-2 inch in diameter; heating surface in fire-box and flues, 23 square feet, and grate surface, 160 square inches. The cylinders are 3 inches in diameter, 4 1-2 inch stroke; driving wheels, 14 inches in diameter, 1 inch tread wheels, 8 inches diameter; wheelson the tender and car, the same as truck wheels. The tender is mounted upon 6 and the car upon 8 wheels. The car will seat 16 grown persons comfortably, but has, at times, carried 32. Width of track, 18 inches; weight of engine, 1300 pounds; weight of tender, with fuel and water, 450 pounds, car 400 lbs.—in all, 2150 pounds.

In reducing to practice the first and most important feature of my improvements, that of using the resistance of the train for the purpose of producing the adhesion requisite to its draft, and at the same time increasing or diminishing this adhesion with the increase or diminution of the resistance, the engine is provided with a pair of horizontal adhesion wheels, these being made to press upon the opposing flat sides of a central rail. (A section of this central rail is represented in Fig. I. Plate II.) This central rail is secured upon a string piece laid along the middle of the track, being elevated in its position somewhat above the side rails, and is to be used only on those parts of the road where gradients are to be overcome, and at water stations, and the usual stopping places, where the side rails are liable to become greasy, and where also the greatest power is required to start or stop the train. In such cases the adhesion wheels are made use of to propel the train. They have their bearings in levers connected together by opposing toggle joints or progressive levers, to which the connecting link of the train is attached. The adhesion wheels are shown at B. in Plate I. and a plan of them with their levers and attachments is shown in Fig 2. Plate II. They are driven by the auxiliary cylinders C. (Plate I) through the intervention of the bevel wheels, E, E, E, E, (Plate II.) When these adhesion wheels are used as drivers, the weight or the resistance of the train is made to operate by means of the toggle I. the engineer having turned the cam J, so that the sliding bar K, to which the train is attached, is permitted to operate against the pin of the toggle I. The engine is now made to advance by the lower cylinders, operating upon the common driving wheels, while the train, instead of being drawn by the frame of the engine, through the intervention of the cam J, (when in the position represented in Fig. 2,) is drawn by the pin of the toggle I, causing the toggle to straighten, and pressing against the end of the levers L L, which turn upon the fulcra M M, presses the wheels at the other ends of the levers, against the sides of the central rail. In advancing or ascending a grade, the train acts upon the toggle I, and in backing or descending, it acts upon the toggle I'.

The amount of the pressure upon the wheels, is therefore proportionate to the resistance

of the train, under all circumstances, an increase of load, or degree of elevation producing a correspondingly increased pressure, and *vice versa.* This pressure will, however, vary slightly, in consequence of the oscillations of the train when in motion, and in order to remedy this inequality, as well as to enable the engine to ascend a gradient without a train, I introduce the steam cylinder N, (Pl. II.) which causes constant elastic pressure againt the toggle. These toggles are adjustible, so that they may be made to produce any desired amount of pressure. The sliding bar has a slotted or elongated hole through it, so as to allow one of the toggles to be at liberty, whilst the other is in use. The same appliance is made in the connecting rods from the steam spring to the toggle I. The bevel wheels should be made of wrought iron, and in order to permit the free vibrations of the adhesion wheels, so as to accommodate them to the side play of the engine, without causing a surge upon the central rail, or forcing it from its place, the driving bevel wheels are feathered upon the horizontal shaft D, thus allowing them to slide lengthways on the shaft. To prevent the bevel wheels from going too deep into gear, or otherwise moving from their pitch-line, plain bevel faces are made to roll together at the pitch-line, the surfaces being kept in contact with each other by means of a spiral spring upon the shaft, between the bevel wheels. In the model engine, the adhesion wheels are 6 inches in diameter, and the gearing is arranged, so that when the engines which drive them, make the same number of revolutions per minute, as the engines which operate the side driving wheels do upon the level road, the engine and train shall advance at a speed of one third of that on the level. In this manner the same volume of steam is used upon the gradient, as upon the level, and the power is increased in proportion to the diminished speed of the train. The rapid exhaust of the auxiliary cylinders, maintains the intensity of the blast whilst ascending the grade, and consequently enables the boiler to generate an adequate supply of steam, so that a deficiency of steam cannot occur on the gradients, which, would be the case, if the blast were diminished by the smaller number of revolutions per minute, and consequently less rapid exhaust.

But at the same time, while I am using the auxiliary engines, and drivers, I do not lose any of the effective power, due to the ordinary engine with the ordinary drivers, and therefore, whatever power they possess, is to be added to that produced by the auxiliary machinery. The resistance to be overcome by the engine on the level road, is the friction of the machinery of the locomotive, and cars, and the resistance of the atmosphere. The first of these is constant, whether on the level or on the grade, the latter varies with the speed, increasing greatly with the increase of speed, and *vice versa.* If the locomotive, therefore by its ordinary drivers, carries its train over the level road at any considerable speed; it has to overcome these resistances, and, as one is greatly diminished by the decreased speed when on the gradient, we may state as a general principle, that on all grades, the adhesion, and power due to the ordinary engines, even of comparatively very light weight, will be adequate to overcome the atmospheric resistance, and the friction of the train, besides carrying a portion of the load, whilst the auxiliary engines overcome the resistance due to the gravitating tendency of the train, or so much as is not overcome by the ordinary engines, and as they move rapidly, they in conjunction with the others, consume and generate steam to the full capacity of the boiler, thus developing the power of the engine most completely and economically.

In constructing the model engine, some improvements were introduced, which will be beneficial to the ordinary locomotive. The arrangement of the eccentric and valve gear is such as to permit the upward and downward motion of the axle, on which they are placed, without disturbing the position of the valves, which is found to be so detrimental to the working power of the best constructed locomotives, when running over rough places in the road. This arrangement is not shown in the drawing, but is so simple, that it may be rendered intelligible by a description. The eccentrics are surrounded by bands, which are made to slide up and down with the motion of the eccentric, (or with the play of the axle,) in yokes, which are made to vibrate or slide in such manner, that the sides of the yokes are always parallel with the sides of the pillow-blocks, in which the axle boxes slide, so that the valve motion taken from these yokes is never disturbed, in whatever part of the yoke the eccentric band may be placed.

The working of all the parts of the model far exceeded my expectations. I refer particularly to the workmanship displayed in its construction, and will mention one fact to the credit of those employed in building it. The cylinders are of brass, with pistons with metallic packing, and so well fitted, that, on turning the cranks of the upper pair of cylinders, in a direction opposite to the set of the valve gear, air will be compressed into the boiler in 5 revolutions, to impel the engines with the adhesion wheels and bevel gear back through 4 revolutions.

The safety brake is represented at Figs. 3, and 4, Plate II, and also in its position under the tender in Plate I.

This brake consists of a simple pair of tongs, which are hung to the bottom of the cars by a jointed link, upon which they are free to vibrate laterally for a short distance, but not so far as to prevent their embracing the central rail when they are allowed to fall upon it. They are kept suspended by a chain so long as the ordinary connection of the cars with the train continues perfect. By referring to the drawings, their action will be better understood. Fig. 3, represents the tongs as suspended, ready for use, the rod O, keeping them in their position, by passing through the outer link of the suspending chain; this rod is attached at its other end to the car, in advance by a small chain, which, should the connection between the cars be broken, withdraws the rod, and the tongs falling upon the central rail, will gripe it with sufficient firmness to prevent the descent of the cars. The train which is attached to the longer ends of the tongs, is secured to a stancheon, fastened firmly to the bottom of the car. The griping jaws of the tongs, are bevelled off on the corners which reach the rail first, in order to guide them with greater certainty upon it. The bite of the tongs on the rail, will prevent the cars from descending, this bite being produced by the draft of the car; upon the chain attached to the longer arms of the tongs, which, as they begin to act at the instant of the separation in the train, and before the loose cars can acquire any downward motion, there is no momentum to be overcome, and consequently no damage will accrue to the cars or rails.

There is no absolute necessity of placing more than one pair of these tongs on a train, as one on the hindmost car, with a proper connection of jointed bars extending from the engine to the hindmost car, will arrest the descent of the train should a break occur in any part of it

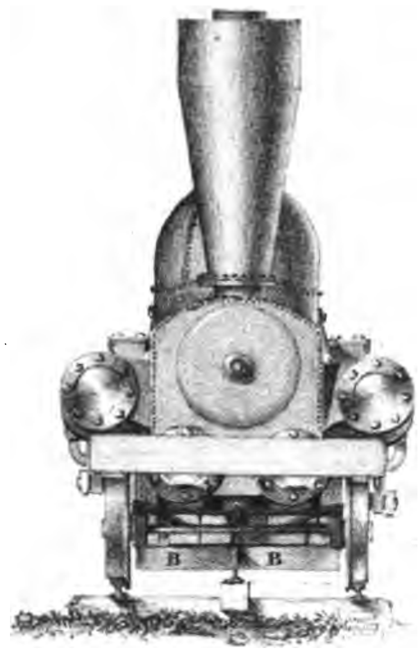
but I should recommend their use on all the cars, in order to guard more effectually against the carelessness on the part of those having charge of them.

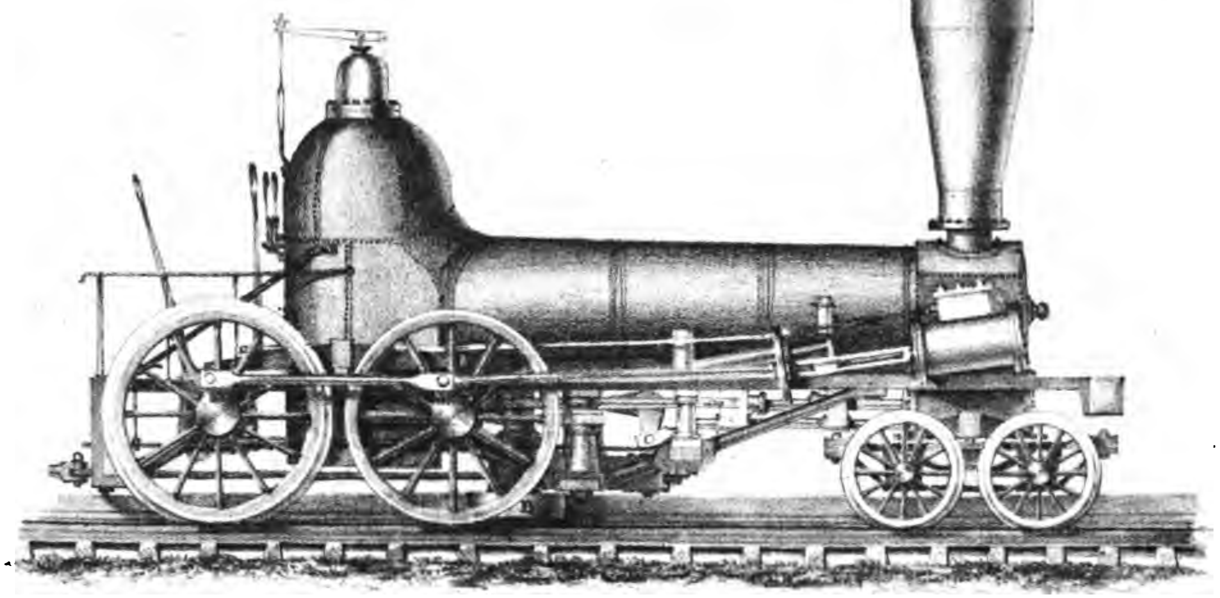
The first experiments with the model engine, were made in Cincinnati upon a track, with grades 5 deg. (460 ft. per mile.) In consequence of the steepness of the gradients, the water in the boiler was required to be kept at such a height in it, in order to keep the flues always covered, as to cause foaming, and consequent loss of power. Immediately before reaching the foot of the gradient, there was a curve of only 30 ft. radius, over which the engine ran with great difficulty, and in ascending the grade, it was required to draw the tender and car round this course, yet, notwithstanding these difficulties, it carried 1800 lbs. up the grade, besides its own weight. In renewing the experiments in New York, the gradient was made at an elevation of 3 degrees, (276 ft. per mile.) The engine performed here most perfectly, the engineer having as complete control, either in ascending, or descending as upon the level road. The entire capacity of the engine has never been fully tested. Thirty-three persons averaging 150 pounds each, have been carried up the grade with the greatest apparent ease, the engine performing all the evolutions of stopping, backing, and starting when on the plane, the steam in the boiler increasing, rather than diminishing, the engineer when exhibiting the performance on the grades, being frequently compelled to open the fire door. The total weight of the load, would thus be 7100 lbs. viz., passengers 4950, engine and train, 2150. The engine started this load with difficulty upon the level road, but acquired considerable speed before reaching the foot of the plane, and to the astonishment of hundreds, who witnessed the performance, it ascended the grade, with very little diminution of speed. Among other experiments on the grade, was that of reversing the driving wheels, and carrying the engine, tender, and car up against the ordinary driving wheels. In one instance this was done by accident with nine men on the car, the adhesion wheels sliding the driving wheels up the plane, thus affording decided proof of the efficiency of the hold-fast of the adhesion wheels, which, in no one instance were ever known to slip. From this last experiment, we of necessity come to the conclusion, that the engine was exerting through the adhesion wheels, a force as much greater than the tractive power of the ordinary driving wheels, as would be necessary to carry the engine and train up a gradient of 276 ft. per mile.

This explains what at first sight appears paradoxical, viz., that an engine should exert a greater power on a gradient than on a level;—on the level it is only exerting the tractive force, due to the weight of the engine on its driving wheels; but when the adhesion wheels, having a much smaller diameter, are used in connection with the side drivers, their adhesion being adequate to the whole steam power, the steam being used in twice the area of cylinder, and the largest portion applied with an increased leverage, the apparent inconsistency vanishes at once.

A locomotive, combining some modifications which possess advantages over the arrangements of the model engine, is represented in Plate III, and a plan of parts of the machinery is shown at Figure 5, Plate II. In this engine the auxiliary cylinders are placed below the smoke-box, where they are not so much exposed as in the model engine. The gripping wheels B, and their vibrating levers, toggles, &c., are placed under the body of the boiler in front of the fire-box, where they occupy a more favorable position for running curves

Plate III





than those in the model engine. This arrangement dispenses with the bevel gearing, which has been objected to by some engineers, although many others do not make any objections to their use; nor can I see that any difficulty will arise from their use at slow speed. This modification will, however, serve to remove all objections which might arise in the mind of any one with regard to the use of the bevel gearing. By referring to Figure 5, Plate II, it will be seen that the engines are attached direct to cranks upon the axles of the adhesion wheels; but, as these axles are separate, the cranks cannot be kept at right angles as in the ordinary engines, where both cranks are made fast upon the same axle. Hence, if by any cause both cranks should come upon the dead point at the same time, the engines would have no power. To obviate such a contingency, I connect the pistons of the engines to a horizontal shaft, upon which cranks are permanently fixed at right angles, the connecting rods and cranks being of the same length as those on the axles of the adhesion wheels. The cranks on the horizontal shaft, being at right angles to each other, will, therefore, keep those on the driving axles in a similar relation to each other. The eccentric gear is placed upon the short horizontal shaft. It will be seen by the drawing, that one pair of cranks work vertically, and the other pair horizontally, and they, with their connecting rods, operate without any interference. This horizontal shaft, having ordinarily nothing more to do than to work the valve gear, may be made very light; but I have represented it in the drawing of sufficient strength to carry the power of one engine to the other, in the event of any accident to either of the engines. In drawing the load, the rail transmits the power of one to the other, precisely in the same manner as two plain wheels working together without any intervening rail.

This change in the position of the cylinders and adhesion wheels admits of an increased length of boiler, which, in engines of great power, will be of material advantage. In the model engine, the cylindric part of the boiler is shorter than the locomotive boilers are usually made, this being done in order to prevent too great a variation in the water level, when ascending or descending a grade. Figure 6, Plate II, represents a form of boiler which admits of any desired length, whilst it gives, at the same time, an increased fire surface. The general internal construction of the boiler is shown by a vertical section through the fire-box. The fire-box is separated from an expanding chamber by a water-bridge, which compels the flame to pass through a contracted space before entering the expanding chamber, where the gaseous products of combustion are ignited previously to entering the flue-tubes. By this device, coal or coke can be used without injury to the flues. The water line is marked at O, O. The flues occupy the entire circle of the body of the boiler, thus giving an increase of heating surface. The top of the body of the boiler is made slanting at an angle somewhat greater than that of the greatest elevation to be overcome. This is done for the purpose of giving free passage into the steam chamber to the steam evolved at the forward end of the boiler, when ascending a gradient. If the body of the boiler were made cylindrical, the steam would rise to the forward end, forcing the water from it into the dome, until the water in the cylindrical part had come to a level with the point P, at the dome end; thus exposing the forward ends of some of the upper rows of flues to injury from excessive heat. By confining the water line to the diameter of the steam chamber, or dome,

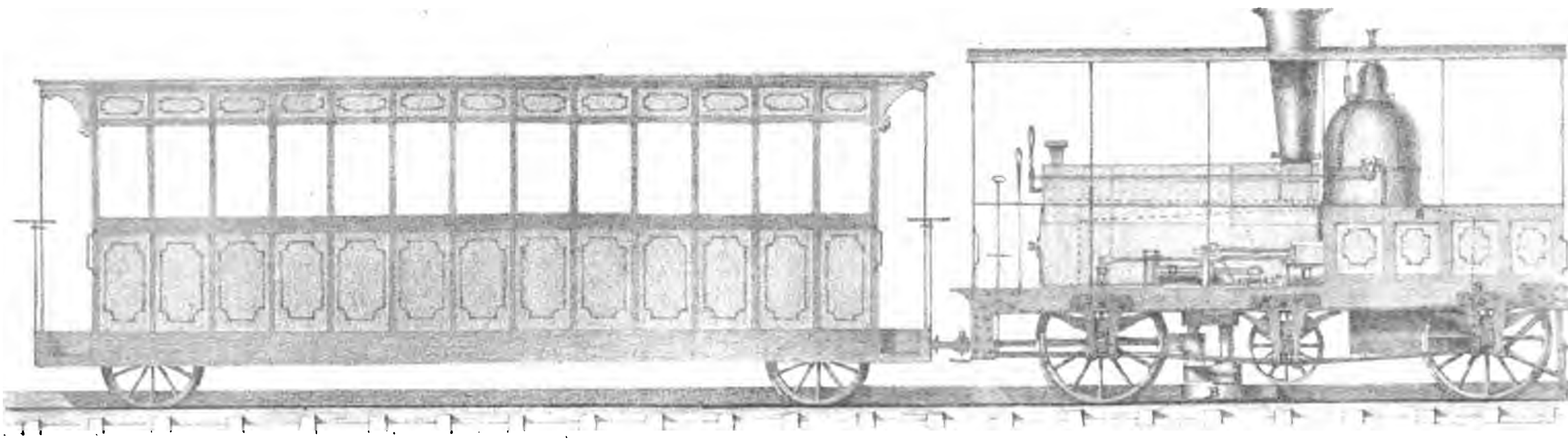
the variations of the level of its surface, from the elevations or declivities of the road, are very slight.

As the steam area is confined to the dome, an enlargement of its dimensions will necessarily be made.

Water, being a bad conductor of heat, is only converted into steam by coming in contact with the heating surface; and a proper circulation of the water, so as to bring every particle of it successively in contact with the heating surface, becomes of momentous importance in the construction of boilers, not only for the purpose of the economical generation of steam, but to prevent foaming or priming, among the causes of which are, an insufficient space to allow the passage of the water from the top of the boiler to the bottom, or the want of a proper balance in the ascending and descending columns. To insure a perfect circulation, I use circulating plates between the fire-box and the outer shell of the boiler, leaving a much larger space for the descending currents outside of the circulating plates than for the descending ones next the fire-box. The descending currents pass round in the space below the grate into the space in front of the fire-box, which is made twice as wide as the other water space, and a portion of the water goes to supply the ascending currents in the water bridge, whilst the remainder passes along the tube or channel below the body of the boiler, and enters at the forward end through openings into it, whence it passes along the whole length of the flues, absorbing their heat, the steam evolved in its progress being delivered along the top into the dome. The rapidity and freedom of the downward currents prevent priming, unless there be dirt or some foreign substance in the water, which can only be effectually remedied by cleaning out the boiler. Water containing any mineral substance should never be used in a locomotive boiler. The globules of steam evolved in the body of the boiler will become so enlarged by constant additions in their course to the dome, as to cause violent ebullition on entering it, which will be effectually prevented by the introduction of a fine grating in the position marked P, Q, which will subdivide the bubbles of steam, admitting them quietly into the dome. The arrows show the general direction of the circulation.

The success attending the introduction of plank roads, which have now been in use for a sufficient length of time to test their durability, and have received a well-merited attention in those parts of the United States and Canada, where nature has so abundantly furnished the materials for their construction, naturally directs attention to the building of rail roads with the same materials; and the question, at once, arises as to their cost and comparative durability. In pursuing this subject, I have made many inquiries of engineers and contractors largely engaged in the construction of Rail Roads, with regard to the durability of the temporary wooden rails used by them in excavation and grading; and I find that they all report favorably to the use of maple and red beech. These woods have been used in some of the heaviest rock cuttings that have been made, where they have been subjected to the severest tests, in consequence of the small diameter of the truck wheels used, and their in-

Plate IV.



sufficient bearing surface on the rails, as also the wear upon the edges, caused by the grinding of the flanges of the wheels. Yet there are now many rails made of both the above-named woods which have been in use for this purpose for more than six years, and exhibit but little wear; in many cases the surfaces have become hard and polished. In the cases referred to, the rails have been on a descending grade, the cars being moved by their own gravity, or by horse power; but when locomotives have been used, the result has not been so favorable; the difference of running over a rail and using it for purposes of draft being very great. Experience has proved that locomotives of comparatively light weight have been very destructive to wooden rails, particularly when the rails are wet. The tractive power, in addition to the weight passing over, causes a separation of the fibres of the wood, which rapidly splits into shreds, or it *brooms up*, as it is sometimes termed.

With this difficulty obviated, have we not in wood a material well adapted to the extension of cheap Rail Roads, on which steam power can be applied with advantage? There is scarcely a section of country where timber, well adapted for the purpose, is not abundant—in the north, beech and maple for rails, hemlock for cross-ties; in the middle and western States an abundance of white oak for ties, and in the south, cedar with heart pine for the rails. Wood receives less injury from broad wheels running over it with the grain, than across it, as in the plank road.

I propose, in view of these difficulties, to lay, throughout the entire length of the road, three lines of rails, using the side rails for carrying rails, and drawing by the middle rail; this middle rail, as well as the others, being notched upon and pinned to the cross ties with wooden pins. For the purpose of better securing the middle rail in its place, let a portion of the weight of the locomotive and cars be thrown upon it by additional wheels. The general construction of this class of engines will be better understood by referring to Plate IV, and, by a description of it, the proposed means of obviating the difficulties referred to will be rendered more clear.

The first object will be to make the engine as light as possible. The one represented in the plate is intended for branch roads, the side rails being plated with light iron, the central rail being of wood. This engine draws its load entirely by the middle rail, the side wheels being used only as carriers. The adhesion wheels are placed under the centre of the engine, and are marked B, the cylinders are shown at C, the pump at D. The power is carried from the cylinders to the adhesion wheels by connecting rods from the piston rods to horizontal vibrating beams under the platform at the back end of the engine, and from thence to the crank wrists at the upper end of the shafts of the adhesion wheels. The fireman and engineer are at the opposite ends of the engine. The bins for carrying fuel are placed at the front part of the engine, on each side of the fire-box, extending as far back as the cylinders, having ample capacity for an hour's consumption. The dome, or steam-chamber, is not placed immediately over the fire-box, but somewhat back, and more directly over the expanding chamber. The fire-box is designated by the line S, S. The heat, after passing through the flues, is returned around the outside of the body of the boiler, and between it and the water-tank, by which means, the ouside of the boiler is covered with a more per-

fect jacket than could be made by any non-conducting coating, the surplus heat being, at the same time, communicated to the water in the tank, and thus facilitating its conversion into steam, when thrown into the boiler by the pump. The adhesion wheels are hung in vibrating levers, very similar to those used in my combined engine, having lateral play, so as to accommodate themselves to the inequalities of the middle rail, as well as the side motion of the engine on the track. In this engine the steam spring serves an important use; for without it, or some analogous arrangement, the engine cannot be made to advance so as to bring the resistance of the cars to bear upon the toggles. I prefer the use of toggles for producing the pressure on the central rail, to any arrangement of bent levers, since the pressure produced by the toggle is, as nearly as possible, a dead pressure, whilst, at the same time, it possesses sufficient elasticity to allow the wheels to open and pass over any inequalities in the thickness of the rail. As it has been shown before, that the pressure upon the central rail has no tendency to move it laterally from its position, it is only necessary to prevent its being raised up from the pins which secure it to the cross-ties; which end is effectually accomplished by placing part of the weight of the engine upon the wheel immediately in advance of the adhesion wheels, the springs on the axle of which wheels are adjusted so as to bring any desired amount of weight upon the middle rail. The engine represented in the plate, with its complement of fuel and water for one hour, will weigh about eight tons. The carrying wheels are four feet in diameter, the adhesion wheels three feet, the cylinders fifteen inches in diameter, sixteen-inch stroke. The cylindric part of the boiler is twenty-four inches diameter, grate surface seven feet, heating surface three hundred and ninety-two square feet, and, with the surface of the return flue around the top, will be over four hundred square feet, which will be sufficient to work the engines on the gradients at full stroke.

The only variation to be made in this engine for plank Rail Roads, or those with wooden rails alone, will be to use engines of lighter description, giving the carrying wheels broader surfaces on the rails, and employing horizontal guide wheels against the sides of the centre rail, to keep the flanges of the carrying wheels from grinding against the sides of the rails. The carrying wheels, particularly upon the cars, should have flanges, so that the cars may be transported along the iron tracks of the main roads, instead of unloading their freight at the junctions. The gauge of the wooden roads should exceed that of the iron rail roads about two inches, the flanges of the wheels being suited to the gauge of the iron track. When roads cross on the level of the Rail Road, the central rail will be left out the width of the crossing, and the track should be laid sloping each way to the crossing, at a grade sufficient to allow the train to run by its own gravity. A similar arrangement is to be employed at the turn-outs. At such places, the track should be narrowed and plated with iron, so that the train will be guided by the flanges on the wheels, whilst passing over that part of the road where there is no central rail. On approaching such places, the engineer shuts off the steam, allowing the engine and train to move on by their momentum and gravity; he then throws down a treddle, which shuts off the steam spring, and suspends the action of the trains upon the toggle, and, as soon as he has reached the central rail, restores the action of all the machinery, and proceeds as usual. The ends of the cen-

tral rail are here tapered on the sides and top so as to present the least possible resistance to the advancement of the adhesion and bearing wheels upon it.

This mode of crossing roads is proposed, as some engineers may object to building bridges over the Rail Road at all the crossings; but, if left to my own judgment, I would not employ it, nor cross any Rail Road on the level of its track. Every State, in granting charters for Rail Road Companies, should require all crossings to be bridged, and thus prevent the many accidents that are continually occurring on level crossings.

The introduction of the horizontal guide wheels may be objected to as an increase of machinery; and as no increase of machinery, requiring additional attention, should be admitted without proportionate advantages, I undertook a series of experiments in order to ascertain the difference between the friction due to the action of flanges upon the rails, and that of guide wheels. After a great number of experiments, I find the practical difference rather more than ten per cent. in favor of the use of guide wheels.

The advantages resulting from the use of the central rail, for wooden Rail Roads is very obvious. In the first place the side rails are relieved from the wear caused by the traction of the locomotive, secondly, they are relieved from the grinding action of flanges upon their sides, besides a saving of ten per cent in friction; thus by the use of light engines, of weight not exceeding that of the cars, the side rails will be more durable than the plank road as now made. The central rail has very little weight to carry, and presents broad surfaces on which the adhesion wheels act, and is not so liable to injury from the traction of the locomotive as the side rails are, as an examination of the matter will show clearly. In the first place, the nature of the adhesion is such, that a less amount of pressure upon the rail, is required to do the same work, and, secondly, the tractive power of the locomotive is exerted upon that part of the rail, upon which water will not lie, and consequently ***brooming up*** cannot take place to the extent that it does on the side rails when used for the purpose of traction. A division of labor, so to speak, is thus effected, the greater part of the weight being distributed upon the side rails, and no traction being required of them: the central rail doing all the traction, and bearing but a comparatively small portion of the weight, thus adding greatly to the durability of the road, as far as wear is concerned.

The cost of construction of Plank Roads, in the most favorable situations, does not exceed $1500 per mile.

The amount of timber used per mile in laying a single track plank road, 8 ft. wide, of planks 3 inches thick, is 168,960 ft. board measure which at 5 dollars per thousand feet is $844.80. A single track plank Rail Road, with side rails 8 inches square, centre rail 5 inches by 12, will require 82,720 ft. board measure per mile, which at 5 dollars per thousand is $413.60, to which add 2640 cross-ties at 10 cents each, will make the cost of the timber for the Rail Road amount to $677,60 being $167.20 less than that of the plank road. The price named is that at which the timber could be furnished in the most favorable locations. In some parts of New York and Canada, 4 dollars per thousand is paid for white hemlock. The advance in the price of timber makes the difference still greater in favor of the plank Rail Road. For instance, suppose the timber costs $10 per thousand, the timber for the plank road will amount to $1689.60; that for the plank Rail Road will cost $827.20, and 2640 cross-ties at 15

cts. each, will be $396.00, in all $1223.20, which leaves a balance in favor of the plank Rail Road of $466.40. No estimate is here made for turn-outs, as they will be about equal in both cases. The grading will likewise be very nearly, if not quite, equal in both cases. All grades under 200 ft. per mile, can be more profitably worked by steam than by horse-power.

In the foregoing remarks and description, I have endeavored to treat the subject in such a manner, as to render the nature and advantages of my improvements perfectly clear and intelligible to persons who are not practically acquainted with the subject. Their adoption becomes a mere question of economy; since, the principle being correct, the advantages resulting from its adoption become a matter for calculation from data, with which engineers are familiar. For this reason I have purposely omitted calculations or formulae, which would only tend to distract the mind of the common reader; nor will the confined space of a pamphlet permit their introduction, except at the expense of other matter of vastly greater importance. I deem it necessary here to dwell at some length upon the nature of opposing adhesion, and to consider some points in which economy will be gained by its application.

I have had an opportunity of testing the efficacy of opposing adhesion upon a bar of iron, by means of a vertical forge-hammer, which I erected in the Globe Rolling Mill in this city. This hammer, weighing with its face and lifting bar about 1 ton, is lifted vertically by means of 2 plain wheels pressed against the opposite sides of the lifting bar attached to its upper end. It is used for 6 puddling furnaces, and one scrap furnace, and has been in constant use day and night for nearly three years. The adhesion or lifting wheels, are 2 feet in diameter, with 4 inch faces. The hammer strikes 55 to 60 blows, 22 inches high, per minute. The lifting wheels are so geared, that power is applied to both of them; using their united adhesion. The pressure is made by a spring which is adjustible by a screw, and is found to be much less than was at first supposed necessary to produce the requisite adhesion. By means of some experiments instituted upon a model, in order to ascertain the amount of pressure required, it is found that at slow speed, with the wheels just from the lathe, corresponding in roughness to the tire of a locomotive driving wheel, and the lifting bar in a state of roughness similar to that of a rail, a pressure equal in amount to double the weight to be lifted was sufficient—and on polishing the wheels and rod, and thoroughly greasing their faces, a pressure of three times the weight to be lifted was required.

On applying the power to one of the wheels only, and using the other as a friction wheel to keep the lifting bar against the face of the iron to which the power was applied, the pressure required to produce an adhesion sufficient to raise the same weight, was rather more than double the amount required when the power was applied to both wheels:—theoretically the pressure should have been precisely doubled, the additional amount being required to overcome the friction due to the axles of the other wheel.

These experiments with the hammer, demonstrate the advantages derived from opposing or, (as I have elsewhere termed it) balanced adhesion, to be much greater for purposes of locomotion than would be at first supposed. A locomotive, when the rails and wheels are

in the best condition has an adhesion of one-fifth; that is to say, five tons' weight upon the driving wheels, will be sufficient to lift one ton vertically; and when the rails are greasy or wet with dew, the adhesion is only one-tenth, or one-twelfth; and when coated with ice one-twentieth of the weight.

The great difference existing between the ***balanced adhesion by pressure*** and the ***adhesion by weight***, is accounted for by the fact that the rails cannot, from the nature of the case, be laid so firmly that they will not yield under the weight imposed upon them; which, if it does not diminish the amount of the adhesion by their springing from the weight when in motion, causes at any rate an expenditure of tractive power in overcoming a constant succession of depressions, in the line of rail;—whereas, in the case of the adhesion on the opposite sides of the rail, this cannot occur, and consequently the full tractive power is exerted in moving the train.

Among other plans which naturally suggested themselves for applying the balanced adhesion, was that of using wheels upon the sides of the ordinary rails; but I became at once satisfied, that the use of a central rail would be more economical, as the employment of the side rails for this purpose would require a modification in their shape, which would increase their weight probably as much as that of the central rail; besides the horizontal drivers projecting on the outer sides of the rails, would present a very serious objection, on account of obstructions; or if the rails were elevated, still the same objections would hold, which induced me to abandon a plan which I proposed when engaged in locomotive building in 1836—37, which was,—to make a side rail, with a flange projecting either inwards or outwards, and to elevate the rail either upon string pieces or on piles, to a sufficient height to allow small friction wheels to be placed beneath the projecting flange, and immediately under the driving wheels; these friction wheels being drawn up by a lever, or otherwise, against the flange to produce an additional adhesion of the driving wheels to the upper surfaces of the rails. The first objection urged against this plan by engineers, was the difficulty of securing rails so elevated against the side surging of the locomotive and cars; the next, the increase of weight in the rail, without any increase of strength or durability; and the most weighty of all objections, is that these friction wheels are not drivers, and although they have as much adhesion to the rail as the drivers, that adhesion is not made use of; and the friction on their journals only adds to the load upon the engines. Besides, the increase of mechanical power by the smaller diameter of the horizontal adhesion wheels, as in my combined engine, could not be attained by this mode, even, although the friction wheels be geared so as to be used as drivers, saying nothing of the complication of machinery required to effect that object.

The position of the central rail offers incidental advantages, which should not be overlooked; being elevated, it will be clear of the snow in many cases; and any ice or sleet, which may form upon the sides, will be easily thrown off, and will fall out of the way. There will be no greater care or difficulty in securing the central rail in its place, than the ordinary side rails require:—it having been shown that the adhesion upon it, and the manner of the attachment of the train, have no tendency to move it from its position, but on the contrary to keep it in it, and at the same time, to render the motion of the engine more steady.

The class of engines represented in Pl. IV. will be best adapted for roads in the mining districts, and in those sections of country, where cheap Rail Roads, if any, will be made. These may be made light and cheap, and as the machinery is simple, will be easily managed and kept in order. The side drivers are dispensed with, as a comparatively small portion of the roads will be level, and the speed and power will be best regulated by means of the adjustible cut-off valves.

Where locomotives of great power are to be constructed either for iron or wooden Rail Roads, it will be necessary to employ two or more sets of adhesion wheels, either geared together, or connected with each other by the usual series of connecting rods, commonly used in locomotives.

We come now to consider briefly the economy of the system at present in use, compared with the one proposed. A locomotive is generally required to carry its train over all the gradients on the route, and the train is therefore limited to the capacity of the engine on the heaviest gradient, although the engine has sufficient weight on its driving wheels to enable it to draw a much heavier train over the levels or very light gradients, say 20 ft. per mile. An engine can also maintain at a high speed, when once set in motion, a train much heavier than it can start from a state of rest, on any part of the road, and more particularly at water-stations, and the usual stopping places, where the rails are always more or less greasy, dirty, or otherwise out of order;—thus, in order to overcome these difficulties, an extra amount of weight is given to the engines, which must be carried back and forth over the road, consuming a proportionate amount of power, and which is not only unproductive, but is the cause of damage to the rails and to the engines, requiring constant and expensive repairs.

It has been before remarked, that the use of heavy locomotives requires an additional weight in the rails and strength of superstructure; the cost of which throughout will greatly exceed that of the additional central rail on the gradients and stations. On gradients especially, where a high speed cannot be had, lighter side rails may be used, so that the weight of the central and side rails will not exceed that of the side rails at present. And in cases where it is important that the road shall be built at as small cost as possible, the expense of the central rail will be as nothing compared with that of grading.

The English engineers, who have probably gone farthest in the use of heavy engines, are beginning to find that the wear of the rails far exceeds any estimate that had been made, and the cost of repairs, per ton carried, for heavy engines is greater than that of lighter ones; some branch roads losing money from these causes alone. They are, therefore, commencing a reform which will, no doubt, be radical.

It will be seen that, by the system here proposed, the engines will carry their trains in those places where the greatest amount of power is required, by means of the horizontal adhesion wheels, which owe their tractive power to the resistance of the trains; and, on the level roads, the train will be kept in motion by the tractive power of the weight of the locomotive; thus economically developing the capacity of the engines to their fullest extent, and dispensing with the enormous unproductive weight of the locomotive, and, in lieu thereof, increasing the amount of productive load carried, or augmenting the speed with the

same load. A moderate reduction of the weight of the cars and running gear may also be effected, which, together with the great reduction in the weight of the locomotive, will diminish the amount of unproductive load to a very considerable extent, amounting, in some cases, to one half, or even more. This will be of very great importance, in Plank Rail Roads particularly.

I am fully aware of the difficulties incident to the introduction of new plans, however useful they may ultimately prove; old prejudices, as well as individual interests, operating strongly in opposition thereto, and the more so, when it is proposed to effect a radical change in a long-established system. In the present instance, however, as far as I have been able to bring these improvements before intelligent engineers, they have given them a reception and appreciation which is highly flattering.

The American Institute appointed a committee of Engineers, who, after examining the plans, and witnessing the performance of the model engine, made a favorable report, and, at their last annual exhibition, awarded for the improvements a gold medal.

APPENDIX.

Letter from HORATIO ALLEN, ESQ., *Consulting Engineer of the New York and Erie Rail Road.*

NOVELTY WORKS, NEW YORK, Aug. 2, 1848.

G. E. SELLERS, ESQ.—DEAR SIR,—I have examined with interest the plans of your locomotive for ascending heavy grades, and have seen in operation the working model, taking more than 2,500 lbs. up an ascent of two hundred and seventy-six feet per mile.

There does not appear to me any room to doubt the entire success of your plans. The means to be used are of a character to be brought into action with great facility and security, and will be as easily kept in order as the other working parts of a locomotive.

Your arrangements are, in my opinion, decidedly superior to all plans that have been proposed or tried within my knowledge, for the same object.

As a substitute for inclined planes, under many circumstances, and as the means of introducing rail roads of small cost of construction, especially in branch roads to the great rail roads of the country, it appears to me that your invention promises to be of great public utility; and I shall take great pleasure, as far as in my power, in aiding in its introduction when the circumstances are suitable.

Yours respectfully,

HORATIO ALLEN.

Letter from JOHN B. JERVIS, ESQ., *Chief Engineer of the Hudson River Rail Road.*

OFFICE OF THE HUDSON RIVER RAIL ROAD COMPANY,
NEW YORK, Aug. 29, 1848.

I have examined a working model of a locomotive engine, by Mr. Sellers, of Cincinnati, designed to draw heavy loads up steep grades on Rail Roads.

The machine is ingenious, and promises to be useful in accomplishing the object for which it is designed.

JOHN B. JERVIS,
Chief Engineer.

The following is an Extract of a Letter from William Norris, Esq., *Locomotive Builder, to a Gentleman largely interested in Rail Roads.*

"The chief objects of his improvements, which I have had an opportunity of examining closely, are to work high grades, or inclined planes, with the same efficiency, certainty, and facility as levels are now worked by locomotives of the present construction—I have no hesitation in saying that he has succeeded completely.

"From my knowledge of this improvement, I can see no difficulty in working gradients of one hundred and fifty to two hundred feet, or more, per mile, most successfully."

Letter from C. B. Stewart, Esq., *New York State Engineer.*

State Engineer's and Surveyor's Department,
Albany, N. Y., Nov. 21, 1848.

G. E. Sellers, Esq.—Dear Sir,—I have examined, with great satisfaction, your "Improved Locomotive," for ascending heavy grades, or inclined planes; and beg leave to say, that I consider its early introduction into general use of much importance to the Rail-way Companies of this country, especially where their gradients are over thirty feet per mile.

I trust you will find no difficulty in having its merits appreciated and tested by the intelligent Rail-way engineers of the United States.

With respect, I remain, truly yours,

C. B. STEWART.

Letter from Benj. H. Latrobe, Esq., *Chief Engineer of the Baltimore and Ohio Rail Road Company.*

Baltimore, September 13, 1848.

Geo. Escol Sellers, Esq.—Dear Sir,—During a recent visit to New York, I had the pleasure of witnessing the performance of a model locomotive engine, designed and constructed by yourself, with the view of acquiring increased power and adhesion upon Rail-ways, especially those of high gradients. The exhibition was very interesting to me, and the reflections to which it led, have satisfied me, that you have effected a valuable improvement in the application of locomotive power to the rail-way, under certain circumstances. By the use of the third or auxiliary rail, and the horizontal adhesion wheels, of smaller diameter than the road wheels generally used as drivers, you accomplish two objects:

1st. The power of augmenting adhesion at all times to any desirable extent, so as to enable the engine, in any state of the weather and of the rails, to exert its full power in moving the train.

2d. The mechanical advantages of applying the power through a small wheel, and the maintenance of the speed of the pistons at the velocity of greatest useful effort, and necessary, also, to keep up the action of the fire, and generation of steam by the exhaust; thus letting the reduction of speed, resulting from the increased resistance on the ascent, be felt in the motion of the train only.

These are highly important points gained, and, obviating existing objections to high gradients, will lead to the shortening and cheapening of lines of rail-way through mountainous countries, and to economy of time, and in the expenses of transportation, and in maintenance of the road. I would, however, confine the application of the machine to the higher gradients, say to those exceeding about fifty feet per mile for

freight, and eighty feet for passenger trains, and of such length as to allow them to be conveniently worked altogether by the improved engine, as distinct stages of the line. Your engine may thus be made to operate entirely through the horizontal adhesion wheels, dispensing with the additional cylinders, rods, and other parts required to connect them with the road wheels, and the latter with each other, and the machine will thus be greatly simplified, and cheapened in its structure and operation.

I see no difficulty in laying and securing the auxiliary central rail, which need not ordinarily exceed forty-five or fifty lbs. per yard in weight.

I do not, however, perceive how crossings of the track by other roads, *upon its own level*, can be provided for. This is, indeed, not an indispensible point, as Rail Roads never ought to be crossed in that way; but it affords an additional reason why the use of the improvement should be confined to the special cases indicated. And yet its universal application, in connection with the abandonment of the *flanged* wheel upon cars as well as engines, and the substitution of horizontal guide wheels, operating like your adhesion wheels against the central rail, is a result which time may possibly bring to pass.

With cordial wishes for your success, I am, dear Sir, respectfully yours,

BENJ. H. LATROBE.

Letter from T. Willis Pratt, *Civil Engineer.*

Springfield Locomotive and Car Factory, Sept. 10. 1848.

Dear Sir,—* * * * * * * I have no doubt of the practicability of your plan for ascending steep grades, as the adhesion of the wheels to the central rail can be increased to any desired extent. *And this is the foundation of the movement of all Locomotive engines.* The speed is determined by the magnitude of the boiler, and economical use of steam in the cylinders ; for there, as I understand, you do not propose any essential changes. We then have this proposition : the ordinary locomotive has a limit to its power, which amounts, we will say, to one-sixth of the weight resting upon its driving wheels ; with your improvements, this limit may be increased, so as to be equal to its whole weight upon the rails : now, the same steam power can give motion to the maximum load, in this case, as well as in the other, though we know that the speed will not be the same as in the first case—you do not claim any multiplication of power but a better means of holding that power, to make it of effective service, and, thereby, you can ascend an inclined plane with your machine with a load, when the ordinary locomotive could not ascend alone,—the ordinary locomotive fails not because its power is not sufficient, but because its hold-fast or adhesion gives way. I saw nothing about your machine to render it impracticable on a large scale ; you have still the simple high pressure engine applied to locomotion with its cylinders, eccentrics, shafts, wheels, &c., which have always worked well, when properly proportioned, and are the standard parts in all engines.

The only difficulty in making any machine practicable, is the want of knowledge or judgment on the part of the constructor or inventor, as regards the strength and proportion of its parts.

I have no doubt that Rail Roads are wanted in many parts of our widely extended country, where the maximum grades must exceed that which is the limit for the locomotive, as at present arranged : your arrangements come very opportunely to show us the means of operating these roads, and, thereby, bringing forth the resources of many of the most valuable mineral regions.

I hope you will meet with success in putting your invention in practice on the ordinary scale of our Rail Roads generally.

Yours truly, with much respect,

T. WILLIS PRATT.

G. E. Sellers, Esq.

Letter from the Superintendent of motive power on the New York and Erie Rail Road.

NEW YORK AND ERIE RAIL ROAD, PIERMONT.

G. E. SELLERS, ESQ.—DEAR SIR,—With pleasure and satisfaction, I have examined your plans and model locomotive for running on heavy grades, and am satisfied that the principles on which it acts, are the true ones, and in my opinion it cannot fail to answer the purpose for which it is intended; in which case it will introduce the use of lighter engines than those now in use, particularly for freight trains, which will be of great importance in the preservation of Rail Roads, and will also greatly extend the use of Rail Roads, as by your plan, roads can be built at comparatively small cost, and in sections of country, where easy grades cannot be obtained unless at great cost; if at all:—your plan will be found particularly applicable in the mining districts.

Your arrangements of the eccentrics and reverse gear are good, and are a decided improvement.

I was particularly pleased with your boiler intended for your high grade engine, which in my opinion is equally applicable to any engine; saving, as I have no doubt it will, at least one-fourth of the fuel, at the same time, that it will prevent foaming, which I consider very important.

If I can render you any service in the introduction of your improvements, it will give me pleasure to do so.

Yours respectfully,

JOHN BRANDT.

Letter from Professor R. M. PATTERSON, *Director, and* FRANKLIN PEALE, *Coiner of United States Mint.*

DEAR SIR,—We have examined with care your device for ascending grades, by the locomotive engine. The principles on which it is founded are evidently sound, and the whole arrangement such as to promise success. In consideration of the ingenuity and plausibility of your plans, and the great importance of the object in view, we most cordially join with the distinguished Engineers, who have already expressed their opinions to you, in stating that we deem your plan every way worthy of a trial on a large scale, and in actual business practice.

Very respectfully, and truly yours,

R. M. PATTERSON.
FRANKLIN PEALE.

G. E. SELLERS, ESQ.

Letter from PROFESSOR O. M. MITCHEL, *of the Cincinnati Observatory, Engineer of the Cincinnati and St. Louis Rail Road.*

CINCINNATI, March 14, 1849.

DEAR SIR,—I have examined your new locomotive with "adhesion wheels for ascending high grades," and have witnessed some experiments with your model engine.

These experiments were entirely successful, so far as the action of the adhesion wheels was involved, as well as in the action of the "Grippers," in saving the train (in case of accident,) from the effects of a swift descent. The slight difficulty arising from the displacement of the water in the boiler on an inclined plane, having been removed in your new boiler, seems to remove every objection which presented itself at the time of the experiments.

I look upon your invention as one of the greatest value, in case it may be effectual in removing the necessity for heavy locomotives. If adhesion may be obtained from your auxiliary wheels (and of this there remains no doubt), light locomotives may take the place of the heavy ones, which are now rapidly destroying even the best constructed roads in our country. Locomotives have been increased in weight to obtain adhesion. These vast machines running at high velocities and over roads imperfectly constructed, must produce the most disastrous effects.

I shall look with great interest to the introduction of your improvement, on a scale which may test its advantages; and, so far as I have examined the matter, I cannot doubt that the results will be of the greatest importance to the public, in the substitution of light for heavy locomotives, and in the construction of cheap roads over broken and mountainous regions of country.

Very respectfully yours, &c.,

O. M. MITCHEL.

G, E. Sellers, Esq.

Extracts from the Eureka, *of September* 20, 1848.

"We have had the pleasure of witnessing some highly interesting and satisfactory experiments on a model rail-way, a portion of it being on an incline of two hundred and seventy-six feet to the mile. Up this grade we saw a small locomotive, weighing about 1,300 lbs., ascend, drawing a train, which increased the weight to about two tons, with the greatest ease. Besides this, we saw all the various evolutions performed, which it is stated in the foregoing description as being capable of doing, viz. stopping and starting the whole train *anywhere* on the inclined part of the track; disconnecting parts of the train, in order to show the effect of the safety-gripping apparatus, by immediately arresting the downward motion of the disconnected cars, and holding them firmly in a state of rest. All the other arrangements described were fully carried out, and, to our apprehension, satisfactorily. We cannot but believe that this invention, once adopted, will be the means of introducing rail roads in many places where they would otherwise never have existed, or, at any rate, not for years to come. The way this is to be accomplished is by being able to go directly *over* hills, instead of being obliged to cut through or go miles out of the direct way, in order to avoid such obstructions.

"Besides ourselves, there were present to witness the experiment, many of our most experienced rail road constructors and engineers, who did not hesitate to give it their hearty approval."

Extracts from an Article by D. K. Minor, Esq., *late Editor of the American Rail Road Journal, which appeared in that paper, September* 2, 1848.

"We accidentally witnessed some interesting experiments, when in New York, a few days since, with a model locomotive engine, designed to show the practicability of taking any load over grades of *one* or *two hundred* feet to the mile, with a locomotive, which it will take on a level road; and thus reduce immensely the cost of constructing rail roads. Various plans have been heretofore devised to effect this object, but none that have been deemed adequate to the object in view, as no one of them has been introduced into use.

"This plan has been invented, and the model brought out, by Mr. George E. Sellers, of Cincinnati, Ohio—formerly of this city, and at one time engaged in the manufacture of locomotives. The great and vastly important objects designed, and believed to be attained by it, are to allow of the use of *lighter* en-

gines upon rail roads, which shall be *more powerful* on *high grades* than the heavy engine now is, and thus to avoid, to a very considerable extent, the rapid destruction of rail roads by heavy machinery.

"It is not always quite safe, we are aware, to form opinions of machinery on a large scale, and to decide important questions of practical utility, upon the working of model machines; yet we were led to examine this machine, and its operations, with some care, as it moved backward and forward on the level portion of the road, laid down for the experiment; and upward and downward on the grade of two hundred and seventy-six feet in the mile; and we were deeply impressed with the opinion that it is destined to exercise a powerful influence in aid of the *extension* of Rail Roads in this country. The statement of one fact—*if it be a fact*, and we do not doubt in the least—will, we think, convince most persons that it will give a new impulse to, and rapid extension of, the Rail Road interest, especially in this country. We were led, by its performance, to believe that a locomotive on this plan, upon a road built, as designed, for its use, with a middle rail on grades, and at the ordinary stopping places, will start a train of cars, and take them over grades of one hundred to two hundred feet in the mile, which it cannot haul, at a profitable speed, even if at all, *on a level road*. This is a bold and startling assertion; an assertion, however, which will be fully verified, if we may safely draw inferences from *these model facts* to practical machines.

"The arrangement of the *additional* machinery of this model is such, that, when put in operation, the adhesion upon the centre rail is in proportion to the *gravity of the entire train of cars*, instead of the *weight* of the *locomotive;* and the beauty of its operation is, that this application of increased power does not add to the wear or injury of the road; as it is brought to bear on the *sides* of the *centre* rail, instead of on the top of the ordinary rails. It has another important feature of great value, in its ability to descend high grades with entire safety, and to arrest and reverse its movement, and ascend or descend at pleasure with its load, on any grade it is designed to work.

"We heard it suggested by a gentleman present, that the surging of the engine sidewise, when in contact with the centre rail, would be likely to remove it from its position; but this objection has been guarded against by the inventor, as will be seen on reading the annexed more full description.

"Mr. Sellers has also provided a 'safety brake' for the cars, in case of their disconnection on high grades, which will effectually prevent accidents, as it arrests their descent before they acquire momentum. We saw the experiment tried with entire success on a grade of two hundred and seventy-six feet in a mile; and the moment the car parted from the engine, the brake fell and clutched the *centre* rail, and held it until the engine backed down and took it again in tow.

"Not satisfied with a single examination, we returned again the next day, for the purpose of verifying, or discarding, our first impressions, and the result was a full confirmation of them.

"There are, probably, some practical difficulties to be obviated, though we are unable to point them out; yet we have little fear but that the mind which has accomplished so much—or some other equally ingenious—will remove them.

"We are fully aware that we are exposing ourselves to remark, perhaps censure, perhaps *ridicule*, in giving these opinions, but we can only say in reply, that the same things occurred on the first publication of this Journal, in January, 1832. It was then said by very wise and discreet men, that locomotive engines could only be used on grades of thirty-five to forty feet per mile, and that Rail Roads could never compete successfully with canals; yet we find that grades of over eighty feet are in common use, and that no new canals are built—and that in England several canals have been converted into Rail Roads—and also, that, in this country, they not only compete successfully with canals, but are destined to compete, and *successfully too*, with the *best river navigation in the world;* and that, too, under the advice and direction of one of the oldest, ablest, and most devoted canal engineers in the country.

"We have witnessed, and closely observed, these changes in systems and opinions during the last sixteen years, and are prepared for, and have been looking for, some important and *striking improvements* in the machinery and management of Rail Roads, by which *economy*, *safety*, and *certainty* will be promoted,

and that thereby a new impulse, and increased utility, will be given to the system. Great powers of mind, and large amounts of capital, have been, for years, directed to this point, and we are quite sure that important results will follow; it may be immediately, or more remote, but it is sure to follow at an early day; and we have no hesitation to say, that, *in our opinion*, Mr. Sellers has made an improvement which will be of vast utility—one which will contribute largely to the safety of passengers, and success of the proprietors of Rail Roads, and that it deserves the early, candid, and intelligent investigation of engineers and Rail Road managers of every part of the country, where heavy grades are a prevention of, or obstruction to, Rail Roads."

Letters Patent for the improved Locomotive and Rail Way have been secured in the United States, England, France, and Belgium, and are held by Calvin Fletcher, Miles Greenwood, and George E. Sellers, trustees for an association. Rights for States, or individual companies, will be disposed of on favorable terms. Application may be made to the undersigned, or to either of the following named Committee, who are residents in Cincinnati.

CHARLES STETSON,
CALVIN FLETCHER,
WILLIAM M. HUBBELL,
JOHN P. FOOTE.

GEORGE ESCOL SELLERS,
Cincinnati, Ohio.

MECHANICAL ENGINEERING.

The undersigned will devote their attention to Mechanical Engineering generally, and to those branches especially connected with the construction of Rail Roads, Mining, and Iron Works.

The experience, which G. E. Sellers has had in erecting Rolling Mills and Iron Works, will enable them to furnish plans for such works of the most approved construction. In offering their services to persons contemplating the erection of such works, they feel assured, that by their personal attention to the business, and intimate acquaintance with all its details, they will be able to erect works, which will combine all the latest improvements.

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GEO. ESCOL SELLERS.
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N. B. Mechanical drawings executed with care and accuracy. Also, analyses of Iron or other Ores made.